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Short Synopsis

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SATELLITE BASED STUDIES ON ION DENSITY IN LOW LATITUDE F2 REGION IONOSPHERE

DEPARTMENT OF PHYSICS
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ABSTRACT

Ion density measurements carried out by satellite (SROCSS-C2 RPA payload) have been investigated and analyzed statistically with varying solar activity ($F_{10.7}$) to study diurnal, latitudinal and seasonal variations in O^+, H^+, O_2^+ and He^+. The present study is carried over low latitude range of 5°N-35°N and 65°E-95°E longitude at an average altitude of 500 km. The ion density values from IRI-2012 (International Reference ionosphere model) obtained from NASA's National Space Science Data Center (NSSDC) would be compared with those obtained from SROSS-C2 satellite. As E X B drift plays a key role in determining plasma distribution and vertical component of geomagnetic field lines become insignificant over the low latitudes, the effect of Geomagnetic activity (Kp) on ion composition would be analysed. The ionospheric plasma distribution gets affected and modulated by various solar – Terrestrial phenomena. Thus the present study would investigate the effects of sub solar flares as solar phenomena on ion compositions. Seismic activity - a well known terrestrial phenomenon has various precursory indicators with ionospheric precursors being youngest. Thus ion density response to seismic activity would be studied to determine small scale irregularities which carry essential importance for human beings in order to mitigate the earthquake disasters.

KEYWORDS: SROSS-C2, Ion density, F2 region, low latitude, solar flares and seismic activity

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1. INTRODUCTION

The lower regions of the atmosphere above Earth's surface have been studied intensively by meteorologists as the seat of the weather phenomena. It is only in comparatively recent times that the comprehensive study of upper regions of the atmosphere have gained the pace. The uppermost layer of Earth's atmosphere is ionosphere where enough electrons and ions are available to reflect radio waves of particular frequencies. Owing to present day dependence of society on satellite communication and navigation, study of ionospheric physics has become extremely important. The very discovery of the ionosphere came from radio wave observations and the recognition that only reflecting layer composed of free electrons and ions could explain characteristics of the data. Ionospheric research has been greatly benefited from the space programs including development of techniques – balloons, rockets and satellites. The combination of ionospheric remote sensing and direct in-situ measurements made from space craft has contributed lot in the field of ionospheric physics.

The Ionosphere is a constituent of the atmosphere where at altitudes in excess of 50 km the earth's atmosphere becomes increasingly rarefied and can support free electrons for short periods. This region has the properties of a gas and plasma which exhibit some interesting effects. Neutral atoms and molecules, such as N_2, N, NO, O_2, O, H and He are ionized by impact of photons of the extreme ultraviolet (EUV) and X-ray radiation, emanating from the sun. Different mechanisms are predominant at specific altitudes; at the outer reaches of the atmosphere the solar radiation amounts to some 1370 Watts per square metre but the density of atoms is low resulting in a small amount of ionization. At lower altitudes atoms are more numerous increasing the rate of ionization but at the same time allowing increased rate of recombination. A further mechanism is the absorption of the incident energy which is a function of the gas density and composition; causing attenuation to increase at lower altitudes. The resultant effect is horizontal stratification denoted as the *D*-, *E*-, and F-layer of the ionosphere.

Electromagnetic high frequency (HF) waves propagating through the ionosphere may experience reflection, refraction, attenuation and modification of the plane of polarization. Reflection of HF waves occurs depending on their frequency, the degree of ionization of the layers of the ionosphere, and on the angle of propagation. The smaller the elevation of the HF wave the higher is the maximum frequency that can be reflected. As characteristic parameter the critical frequency is specified, which denotes the highest frequency that is being reflected at vertical incidence. It is subject to high variability and depends on the production rate of

free electrons, the loss rate which is mainly due to recombination and the transport of the charged particles.

The ionosphere is not only controlled by the radiation of the sun and the coupling with the neutral atmosphere, but also affected by the solar wind, the earth's magnetic field as well as the interplanetary magnetic field and other phenomena. The resulting high variability of the density of charged particles impedes a detailed forecast of the actual ionosphere. Recently it has observed that the electromagnetic flux associated with seismic activity also affects ionospheric phenomena. Different physical precursory indicators – earth degassing, metallic aerosols emanation, ground water uplift, increase in P- wave velocity, anomalous vertical electric field, ionospheric precursors etc can be found reported in literature. Among these precursory indicators, probably the ionospheric precursors are the youngest. Thus to make it a real time precursor more and more statistical work on small and large time scales needs to be done.

1.1 DATA

1.1.1 SROSS-C2 satellite and RPA Payload

The SROSS-C2 satellite was launched with the help of Augmented with the help of Augmented Satellite Launch Vehicle (ASLV-D4) rocket on May 4, 1994 in the orbit of about 930 km x 425 km. After two months of its operation the apogee of satellite was brought down to about 625 km and operated continuously for seven years. The satellite returned to earth on July 12, 2001. SROSS-C2 was the fourth satellite of the Stretched Rohini Series Satellite Programme of ISRO Satellite Center (ISAC), Bangalore. The weight of the satellite was 114 kg, which carried 6 kg hydrazine fuel and generated 50 – watt onboard (Garg & Das 1995). Orbital inclination of the satellite was 46˚ with the equatorial plane. This was spin – stabilized satellite with its spin axis perpendicular to its longitudinal axis and the rate of spin was 5 revolutions per minute (rpm). The satellite moves in the orbit motion keeping the spin axis perpendicular to the orbital plane. In this kind of orbital motion RPA sensors face the velocity vector once in each spin cycle of satellite. The angle Θ between the sensor normal and satellite velocity vector keeps changing from 0 to 360˚ at the rate of 30˚/sec. The RPA measurements are taken when the sensor normal faces the satellite velocity vector. But in a spin stabilized satellite, this situation remains for fraction of second. The RPA sensors collect data within ±30˚ (for ions) and within ±90˚ (for electrons) of the satellite velocity vector once in each spin period.

The Retarding Potential Analyser (RPA) payload was designed and developed at National Physical Laboratory (NPL), New Delhi for SROSS series of satellites. The RPA payload was switched on in orbit first time on May 21, 1992 using SROSS – C satellite through ground commands issued from ISRO Satellite Tracking Center (ISTRAC), Bangalore. Again, on May 4, 1994 the RPA payload placed in orbit by SROSS-C2 mission. NPL was taken up to design and develop the RPA for SROSS series of satellite under SROSS aeronomy satellite project (SASP). The instrument was designed for minimum power consumption, size and weight to have maximum possible reliability and flexibility of its operation in space through ground commands.

The RPA payload consists of two sensors, viz. electron and ion sensors and associated electronics. The electron and ion RPA's are used for *in situ* measurements of ionospheric electron and ion parameters. In addition, a spherical Langmuir probe is included and used as a potential probe for estimating the variation of spacecraft potential during spinning of the satellite. The electron and ion sensors both have planar geometry and consist of multi grid Faraday cups with a collector electrode. The different grids in the sensor are designated as the entrance grid, the retarding grid, the suppressor grid and the screen grid. These grids are made of gold-plated tungsten wire mesh having 90-95% optical transparency. The two sensors are mechanically identical but have different grid voltages suitable for collection of electrons and ions respectively. The charged particles whose energies are greater than the applied voltage on the retarding grid pass through various grids and finally reach collector electrode to cause the sensor current. This current is measured by linear auto-gain ranging electrometer.

1.1.2 Objective of SROSS Mission

The scientific objectives of SROSS mission are (Garg *et al.* 1995):

i. To study the behaviour of electron and ion density and temperature anomaly in the low latitude region.
ii. To study the special features of energetics of the equatorial and low latitude ionosphere.
iii. To establish the response of the thermal structure to the dynamical effects.
iv. To study the effects of magnetic storms and spread F on thermal structure.

For achieving these scientific objectives the RPA payload measured the following ionospheric parameters:

a. Total ion density N_i
b. Ion temperature T_i
c. Ion composition O^+, O_2^+, NO^+, H^+, He^+
d. Electron Temperature T_e
e. Superthermal electron flux (STEF) (upto 30 eV)
f. Irregularities in electron and ion densities
g. Satellite potential with respect to Plasma

Accuracy measurements:

Parameter	**Accuracy**
N_i	±5%
T_i and T_e	±50 K

1.1.3 The Principle of RPA operation

The RPA sensor is analogous to pentode vacuum tube where ionospheric plasma serves as the cathode. The ion and electron enter the sensor through its open aperture and pass through the region, which is electrically segmented by a series of very fine gold plated tungsten wire electrode and then reach the collector electrode. The current thus collected over the collector plate varies from tens of microamperes down to the fraction of pico-amperes. By changing the bias voltage on the retarding grid, different energy electrons/ions reach the collector plate to cause the collector current. This gives the measurement of flux in different energy ranges.

2. LITERATURE REVIEW

The primary source of ionization in the earth's atmosphere is interaction of solar radiation with neutral atoms and molecules. When high energy photons collide with neutrals, they produce positive ions and free electrons. These ions and electrons have energies about tens of electron volts (eV). These electrons can travel long distances and produce more ionization by collision with other neutral atoms and molecules. Solar EUV and X-ray radiations ionize the upper atmosphere to produce the plasma in the Earth's ionosphere. It is well known that solar radiations change over different time scales, which induces corresponding variations in the

ionosphere (Kawamura *et al.* 2002; Rishbeth & Garriott 1969). For example, the most prominent solar cycle variation of solar radiations (Lean *et al.* 2001; Lundstedt *et al.* 2005) modulates significant 11-year change in the ionosphere (Afraimovich *et al.* 2008; Bilitza, 2000; Liu *et al.* 2004, 2006, 2009; Zhao *et al.* 2005).

In addition to photo ionization, the ionosphere is also controlled by recombination and dynamics processes. At equatorial and low latitudes, the F-region is characterized by a depression in ionization densities at the magnetic equator and two maxima on either side of the equator. Besides this well-known phenomenon of equatorial ionization anomaly (EIA), the equatorial ionosphere is known to exhibit some unique features such as the equatorial electrojet, the spread-F, etc. The horizontal orientation of the geomagnetic field lines at the equator and the shift between the geographic and geomagnetic equator are known to be the main reasons for observation of these features and their longitudinal variation. Martyn (1947) put forward the explanation that the E-region eastward electric field at the equator causes the F-region plasma to drift upward during the daytime. As the plasma is lifted to greater heights, it diffuses downward along geomagnetic field lines under the twin action of gravity and pressure gradients (Hanson & Moffett 1966). A plasma fountain thus forms which moves ionization from the equator to the two anomaly crests. Variability occurring during the evening to post sunset and night hours have specific significance, after sunset electric field reverses, and velocity of drift enhances in opposite direction (pre reversal enhancement), thereafter again reverses its direction and reaches downward maximum (Hovarth & Essex 2002), during this process when F region plasma drifts downwards crest disappears. The low-latitude ionosphere at F-region heights has been studied quite extensively in the last three decades for its electrodynamics and resultant ionospheric features (Blanc & Richmond 1980; Fejer 1986, 1991). Mainly from the Jicamarca (11.95˚S; 76.87˚W, geographic) experimental data, the various important characteristics of the vertical F region plasma drift are well known today (Fejer *et al.* 1991). From the model results of SUPIM, the behaviour of equatorial plasma fountain and equatorial anomaly is well understood (Balan & Bailey 1995; Balan *et al.* 1997; Bailey et al., 1997).The Jicamara data indicate, the magnitude of the vertical F-region E X B plasma drift velocity largely depends upon geophysical factors such as levels of magnetic activity, phase of solar cycles and the seasons (Fejer 1991).

Hoegy & Grebowsky (1991) have established a large database in situ ion density measurements from a large number of satellites covering period of 1960's and 1970's. During

the daytime, O^+ is produced in the F region and diffuses upward in the topside. This flux of O^+ into topside causes the O^+ to H^+ transition height to rise above the expected in the presence of chemical equilibrium. Meridional and zonal neutral winds in the F region may act to raise or lower the height of the F peak, which consequently enhances or reduces the O^+ flux into the topside ionosphere (West & Heelis 1996; West *et al.* 1997). Truhlik *et al.* (2006) discussed solar activity in the global topside ion composition based on satellite data from OGO – 6,AE –C, AE –E and IK –24 during the period from late 1960's to early 1990's. Bhuyan & Kakoty (2002) simulated O^+ and H^+ ion density distribution in the topside F-region of the Indian low latitude ionosphere and compared the results with the density measurements made by the Indian SROSS-C2 satellite. Bhuyan & Borgohain (2005) studied diurnal, seasonal and latitudinal variation of ion concentrations as obtained from the SROSS-C2 satellite over Indian low and equatorial latitude during solar minimum. Borgohain & Bhuyan (2010) used Taiwanese satellite FORMOSAT-1 over Indian region and SROSS-C2 to discuss solar cycle variation of ion densities over Indian low and equatorial latitudes.

F region ionospheric affects as a response to solar activity effects is probably one of the most complex study of ionospheric physics, involving the study of all almost all ionospheric parameters. One of the most interesting solar activities is solar flare. Solar flares are magnetically driven sudden explosions from localized active region of the sun's surface (corona), usually near a complex group of sunspots, covering almost entire range of electromagnetic spectrum (Gopalswamy 2009). When associated with coronal mass ejections, solar proton events, solar wind and prominences is termed as geomagnetic solar storm. As the intensity of geomagnetic storm increases, it creates major disaster to earth's ionosphere. All most all the ionospheric layers and parameters are affected by magnetic storm. Many authors have worked to study the geomagnetic storm effects on the ionosphere (Prolls 1995; Rees 1995; Buonsanto 1999; Danilov & Lastovicka 2001; Danilov 2013).

The effect of solar flares on the ionospheric F region has also been studied (Mendillo *et al.* 1974) by VHF radio beacons experiment on geo-stationary satellite and noticed enhancement of TEC. Global observation of outstanding flares of August 7, 1972 using 17 stations in North America Europe and Africa (Mendillo *et al.* 1974) revealed that TEC was increased by 15-30% during the solar flares. The low latitudes showed larger increase in TEC compared to high latitudes. Some events of solar flares have also been studied (Donnelly 1976; Kanellakos et al. 1962) to see the effect on E and F regions of the ionosphere and it was found that electron density was enhanced at these heights. Thome & Wanger (1971) theoretical study

was carried out to see the effect of solar flares on electron density and found that electron density is enhanced in E and F regions of the ionosphere. After advent of GPS, scientists have reported global views of ionospheric solar flares effects by means of GPS technique (Zhang *et al.* 2003; Zhang & Xiao 2003; Liu *et al.* 2004). Instead of global view Zhang *et al.* 2003 examined several flare events and found that for similar classes, flares occurring near the solar meridian result in stronger ionospheric responses. Many researchers (Afraimovich *et al.* 2001; Anastasiadis 1995; Avakyan 2001; Carington 1860; Charikov 2000) have studied the effect of solar flares using GPS and other satellite data. Researchers have studied the effects of solar flares of September 23, 1998 and July 29, 1999 on ionosphere with the help of GPS network. They found that the fluctuation of total electron content (TEC) and its time derivative by removing the linear trend of TEC with a time window, are coherent for all stations on the dayside earth and no such effect of solar flares was detected on the night side of the earth. A brief review on solar flare effects on ionosphere can be found in literature Tsurutani *et al.* (2009). They studied the number of photon and energetic particle effects on TEC and have reported increase in TEC as a response to solar flare associated with energetic particles. Effect of solar flare on ionospheric TEC at Varanasi has been studied by Kumar & Singh (2012). They administered increase in TEC as a response to weak solar flares and dependence of increase in TEC on class of flares.

The seismo – ionosphere coupling is probably one of the most complex and interesting areas of research involving interactions starting from earth's interior to magnetosphere. Different physical precursory indicators – earth degassing, metallic aerosols emanation, ground water uplift, increase in P- wave velocity, anomalous vertical electric field, ionospheric precursors etc can be found reported in literature. Among these precursory indicators, probably the ionospheric precursors are the youngest.

One of the earliest reports related to existing in literature, reporting variation in ionospheric plasma densities as precursory indicators of seismic activity goes back in 1983. Gokhberg (1983) measured onboard AE-C and ISIS – 2 satellite data to report variations in local plasma density and temperature before earthquake. Pulinets *et al.* 1991 observed large scale plasma irregularities over earthquake preparation zone using topside sounders. Hayakawa (2000) statistically analysed larger database of plasma densities using Intercosmos – 24. This report by Hayakawa serves as reliable report, co – relating global distribution of seismic activity and ion density variations as it included larger database (3000 orbits of intercosmos-24 satellite). Afonin *et al.* 2000 reported precursory type significant changes in ion density distribution

pattern over earthquake epicenters at night over ~ 500 km satellite altitude. They found anomalous behaviour in ion density pattern within ± 7 days of strong earthquake. Electron and ion density temperature variations have also been studied by Sharma *et al.* 2013. They registered ~ 1.2 times increase in Te and Ti as an effect of earthquakes.

3. DISCRIPTION OF BROAD AREA

The major ions present in ionospheric F2 region are – O^+, H+, O_2^+ and He^+. Ionosphere has been studied with satellite based techniques from past few decades. However with commencement of satellite era and space based techniques F2 region could be studied more extensively. Indian satellite SROSS-C2 gives an excellent coverage over the low latitude range of 5°N-35°N and 65°E-95°E longitude at an average altitude of 500 km. The equatorial and low latitude ionosphere exhibits many unique features such as EIA (Equatorial Ionization Anomaly), plasma fountain, equatorial electrojet etc. The analysis of ion concentrations/ density with sun's activity ($F_{10.7}$), geomagnetic activity (Kp), solar flares and seismic activity would provide an insight to the behaviour ionosphere when subjected to different influential phenomena. Solar- terrestrial interactions with Earth's ionosphere is probably one of the most complex and interesting areas of research involving interactions starting from earth's interior to magnetosphere.

Photoionization and chemical processes can produce a wide variety of ions in the ionosphere. In F region, from 300 to 500 km, O^+ is the dominant ion and at higher altitudes lighter ions H^+ and He^+ become significant in number. Above at about 1000 km, H^+ ions dominate and the region is called as protonosphere. Above dominant O floats H^+ ions. During night time O^+ concentration diminishes by recombination processes and H^+ ion float progressively at lower levels thus coming into contact with higher concentrations of neutral O which promotes the charge exchange reactions, $H^+ + O \rightarrow H + O^+$. During day time photoionization enhances the O^+ density and reverse reaction takes place with neutral H acting as source. The coulomb friction between moving O^+ and H^+ limits their movement. During day time ionosphere transports its constituents to magnetosphere and reverse processes occurs at night time, i.e. the particles are transported from magnetosphere to ionosphere; known as diurnal breathing of ionosphere – magnetosphere system.

Oxygen and Hydrogen ion concentrations dominate in the regions ~ 500 km. At higher altitudes H^+ is major ion followed by O^+ and He^+. The ion concentrations change drastically with latitude. The morphology and dynamics of ions vary dramatically from mid and high

latitudes compared to low latitudes further resulting changes in wave particle dynamics. Furthermore interaction of ionospheric plasma with geomagnetic field lines is completely different in low and high latitudes. Thus the effect of geomagnetic activity (Kp), solar flares and seismic activity calls for different kind of dynamics from previous works.

Seismicity precursors related to ionosphere are probably the most recent ones. Thus lots of statistical and analytical work needs to be done to make comprehensive system that can warn and predict earthquakes saving life. Answering ionospheric precursors (small and large time scale) needs great deal of understanding the interactions in mantle as well as in magnetosphere. The coupling of lithosphere-ionosphere needs deeper insight proving answers to many unsolved questions and thus help in mitigation in destruction of life and property.

4. OBJECTIVES OF THE PROBLEM

- **To study diurnal, latitudinal variations of ion density with varying solar activity:**

The diurnal and latitudinal variations of O^+, H^+, He^+ and O_2^+ would be carried out using SROSS-C2 satellite's RPA measurements. The behaviour of the ions would be compared with modeled data (International Reference Ionosphere - IRI - 2012) by studying relative concentrations during solar minima and maxima years. O^+ being major ion in F2 region the effect of geomagnetic activity Kp would be investigated on O^+ ion.

- **To study seasonal variations of ion density and to investigate equinoctial asymmetry in ion concentrations:**

Seasonal behaviour of ion concentrations O^+, H^+, He^+ and O_2^+ would be carried out using SROSS-C2 satellite's RPA measurements. Asymmetry in ion concentrations in vernal and autumn equinoxes would be studied as a special case.

- **To investigate ion density response to solar flares:**

O^+ being major ion, the effect of solar flares would be investigated on O^+ using SROSS-C2 satellite measurements and would be compared with IRI-2012 model.

- **To study ion density response to seismic activity:**

It is known that seismic events – earthquakes cause lots of damage to mankind and property. Well established early warning systems like that of cyclones and tsunamis have helped to

save lots of life and property. On similar lines to make earthquake precursory as real time warning system, still lots of statistical work needs to be done on small and large time scales. Using SROSS-C2 satellite measurements effect of seismic activity on ion concentrations would be studied as small scale precursory indicator of earthquakes. The effect on ion concentrations as a response to high and moderate magnitude earthquakes would also be analyzed

5. METHODOLOGY

5.1 Data Source, Selection and Analysis – SROSS-C2 satellite

The RPA data were obtained from National Physical Laboratory (NPL) under the Indian Space Research Organization (ISRO) programme "Scientific utilization of SROSS-C2 data". The raw data have been obtained the form of LOTUS file. These files are divided into months and marked the data corresponding to satellite Orbit number from separate dated files. To study effects of diurnal, latitudinal and seasonal variations; solar flares and seismic activity on ion density over the region (5°N-35°N latitude and from 65°E-95°E longitude), data of year 1995 - year 2000 have been marked.

5.1.1 Determination of Ion Density from Ion RPA Data

For determining the total ion density during a satellite pass, the selected file data sets satisfy the following conditions:

I. The angle Θ should be less than 20˚ or more than 340˚
II. The ion RPA retarding grid bias is Zero volt

The selected is then subjected to Cos Θ correction i.e. ion current is divided by Cos Θ. Then the total ion density is calculated by the following formula

$$N = \eta\, AeU_sI$$

Where, N = Total ion Density, η = efficiency of sensor = 0.5

A = collector area = 20 cm^2, e = electron charge = 1.6 x 10^{-19} C

U_s = Satellite velocity = 7.8 km/sec, I = Cos Θ corrected ion current

5.2 Solar Flares Data

Many agencies may play important role in changing the ionospheric temperature in F2 region. One of them is the solar flare, which directly affects the ionosphere and radio communications on earth and also releases energetic particles into the space. The effect of solar flare on earth's ionosphere has become an important study of the day. For this purpose the data on solar flares have been obtained from **National Geophysical Data Center (NGDC)**, Boulder, Colorado (USA) from the period of 1995 to 1998 in the present study.

5.3 The international Reference Ionosphere (IRI)

The International Reference Ionosphere (IRI) is an international project sponsored by the Committee on Space Research (COSPAR) and the International Union on Radio Science (USRI). The IRI model data for the same period were downloaded from the Internet and used for the purpose of comparison. The IRI describes the median or average value of electron density, ionospheric temperatures (electron, ion, and neutral) and ion composition as a function of height, location, local time and sunspot number. It is an empirical model based on the data from the worldwide network of ionosode stations, incoherent scatter radar, the ISIS and Alouette topside sounders and *in situ* measurements by several satellites and rockets. We would use the **IRI-2012** model to compare O^+ ion and total ion density as ionospheric parameter during the study period taking it as reference level.

5.4 Geomagnetic Activity Index (Kp) data

The region of our concern is comprised of highly variable F region equatorial anomaly. Thus Ion density (O^+) is highly modified according to the movement of Vertical E x B drift. Furthermore bearing in mind that E x B drift movement depends on Geomagnetic Activity, O+ ion density pattern have been compared with geomagnetic activity index Kp. For this purpose the data of geo magnetic index Kp have been obtained from the link OMNIWeb Plus on NASA website *nssdc.gsfc.nasa.gov* - **National Space Science Data Centre (NSSDC)**. The standard Kp values look like 0, 0+, 1-, 1, 1+, 2-, ... but are stored as Kp = 0, 3, 7, 10, 13, ... in the OMNI data set which are mapped as 0+ to 3, 1- to 7, 1 to 10, 1+ to 13, 2- to 17, etc.

5.5 Seismic Activity Data

The seismic activity resulting to earthquakes cause lots of destruction to life and property. Well established comprehensive early warning system is need of the hour. The data of earthquake were downloaded from USGS website – NEIC (National Earthquake Information Center). The mission of the National Earthquake Information Center (NEIC) is to determine rapidly the location and size of all destructive earthquakes worldwide and to immediately

disseminate this information to concerned national and international agencies, scientists, and the general public. The NEIC compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research.

6. EXPECTED OUTCOMES OF PRESENT RESEARCH

- Diurnal and latitudinal behaviour of specific ions O^+, H^+, He^+ and O_2^+ would get determined using SROSS-C2 measurements over Indian sector in F2 region.
- Seasonal variations of specific ions O^+, H^+, He^+ and O_2^+ would get determined using SROSS-C2 measurements over Indian sector in F2 region.
- Equinoctial asymmetry in ions (O^+, H^+, He^+ and O_2^+) would be observed in low latitude F2 region.
- Ion density would get affected due to solar flares.
- Ion density and concentrations would change as a response to seismic activity.

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